# Chapter 15
# Fire Protection Systems

## 15-1. General

Powerhouses are generally low fire hazard structures with special installed fire protection usually limited to the following four specific hazards: oil storage and purification rooms, a paint and flammable storage room, main power generators, and transformers. The principal fire protection for all other areas and hazards is portable extinguishers and fire hoses. Manned fire hoses are not generally relied on as a first line fire protection because of the potential damage to equipment inherent in powerhouses except as noted in paragraph 15-10. The deck washing systems provided in all powerhouses offer limited fire protection in most areas (see paragraph 10-6*h* for further discussion of backup provisions). NFPA Standard 851 and ETL 1110-2-311 provide guidance for fire, protection for hydroelectric generating plants, and hydroelectric power plants, respectively. Fire protection systems using Halons are prohibited.

## 15-2. Oil Storage and Purification Rooms

*a. General.* Oil storage rooms contain large quantities of transformer oil and lubricating oil with the potential for fire. Because of the seriousness of such a fire, an automatic carbon dioxide ($CO_2$) extinguishing system is provided to limit damage within the rooms and to limit the spread of smoke and noxious fumes through the powerhouse. Normal practice is for the design office to perform preliminary design to determine the approximate number and location of $CO_2$ bottles and nozzles, location of controls and piping, and to prepare design memoranda and contract specifications. Final system-design responsibility is normally assigned to the contractor. Safety of personnel should have continuing design priority since the discharge of $CO_2$ can impair visibility, will result in loss of consciousness from oxygen shortage in total flooding spaces, and may impair breathing in low-elevation areas exposed to drifting gas. Planned use of the room should not include storage of volatile, low flash-point materials susceptible to explosion. Miscellaneous combustible materials, especially paper products, should not be stored in the oil storage room.

*b. Room construction.* Oil storage and purification facilities are preferred to be in a common space but may be in separate rooms when required for structural reasons. Rooms should be in mass concrete, but in all cases should be of 2-hr minimum fire-resistant construction with automatic fire doors or dampers at all openings. Where separate rooms are used, independent $CO_2$ systems are usually provided. However, a combined system may be provided where room locations and relative volumes would result in a lesser cost and there is no connecting door between the rooms.

*c. System design.*

(1) General design considerations are as follows:

(a) The system should be a total flooding type with minimum design concentration of 34 percent and without extended discharge.

(b) The amount of $CO_2$ discharged from the nozzle that is effective in extinguishing a fire varies from 70-75 percent of the total quantity of $CO_2$ contained in the cylinder. Therefore, for design purposes, it is necessary to increase the nominal cylinder capacity by 40 percent (see NFPA Standard 12).

(c) A $CO_2$ release should be actuated by a room thermostat, manual operation of a switch outside the room at the exit, and manual operation of a cylinder release.

(d) A 20-sec delay should occur between actuation and release of $CO_2$ from cylinders with a continuous alarm sounding in the room.

(e) A $CO_2$ release should stop oil pumps and fans and close fire doors and dampers.

(f) Piping should be sized to preclude freezing of lines.

(g) Refer to Figure B-16 for a typical $CO_2$ fire protection system.

(2) Detail system design and materials should comply with applicable provisions of NFPA Standard 12 and Corps of Engineers Guide Specification CW-15360.

## 15-3. Paint and Flammable Liquid Storage Room

*a. General.* Projects lacking outside facilities for the storage of paint, lacquers, thinners, cleaners, and other volatile, low flash-point material should be provided with a room in the powerhouse for such storage. Operating experience at some projects indicates a tendency to utilize the oil storage rooms for storage of hazardous materials because of a lack of adequate space in the paint and flammable liquid storage room. Therefore, space in the paint and flammable liquid room should be generous, on the order of 9.3-11.2 $m^2$ (100-120 $ft^2$) of floor area.

*b. Room and system design*. The provisions of paragraph 15-2*a*, *b*, and *c* apply generally except for references to oil and tanks. Refer to Figure B-16 for a typical $CO_2$ fire protection system.

## 15-4. Generators

*a. General.* Generators with closed air-circulation systems should be provided with automatic $CO_2$ extinguishing systems. Up to four generators may be on one system, with $CO_2$ cylinder storage based on discharge in a single unit. Design responsibilities and safety concerns noted in paragraph 15-2 are applicable. Piping within generator housings is normally provided by the generator contractor.

*b. System design.*

(1) General design considerations are as follows:

(a) The contractor shall coordinate his design with the generator contractor to assure that a $CO_2$ concentration of 30 percent will be maintained within the generator housing for a minimum period of 20 min without the use of an extended discharge. See NFPA Standard 12 and Guide Specification CW-15360.

(b) $CO_2$ release should be actuated by the following:

- Generator differential auxiliary relay.
- Thermoswitches in the hot air ducts of each air cooler.
- Manual operation at the cylinders.
- Remote manual electrical control.

(c) Refer to Figure B-16 for a typical $CO_2$ fire protection system.

(2) Detail system design and material should comply with applicable provisions of NFPA Standard 12 and Guide Specification CW-15360.

## 15-5. Motors

Larger motors with a closed air-circulation system are occasionally used in powerhouses. $CO_2$ fire protection should be provided similar to that indicated for generators.

## 15-6. Transformers

*a. General.* Fire protection at a transformer is provided to limit damage to other nearby transformers, equipment, and structure. It is assumed that a transformer fire will result in loss of the transformer. Deluge systems are provided for outdoor oil-filled transformers and $CO_2$ systems for indoor oil-filled transformers.

*b. Outdoor transformers.*

(1) General. Main power transformers are commonly located outdoors, on intake or tailrace decks, in the switchyard, or on an area adjoining the powerhouse upstream wall. They are sometimes individually semi-isolated by walls on three sides. The frequency of transformer fires is extremely low, but the large quantities of oil involved and absence of other effective fire control measures normally justify installation of a deluge system where there is a hazard to structures.

(2) System design.

(a) The system should be a dry pipe, deluge type. Deluge valves should be actuated automatically by a thermostat, manually by a switch in a break-glass station located in a safe location near the transformer, or manually at the valve. Where exposed transformers (without isolating walls) are located closer together than the greater of 2-1/2 times transformer height or 9 m (30 ft), the system should be designed for spraying the adjoining transformers simultaneously with the transformer initiating deluge.

(b) System detail design should be in accordance with NFPA Standards 851 and 15.

(c) The deluge system water supply is discussed in paragraph 10-4.

(3) Figure B-17 presents a typical transformer deluge system.

*c. Indoor transformers.* Oil-filled indoor transformers should be protected in accordance with NFPA 70 “The National Electric Code.”

*d. Outdoor oil-insulated.* Oil-insulated power transformers located outdoors should be provided with chilling sumps which consist of a catchment basin under the transformer filled with coarse crushed stone of sufficient capacity to avoid spreading an oil fire in case of a tank rupture.

## 15-7. Portable Fire Extinguishers

Portable $CO_2$ handheld extinguishers are the first line fire protection for powerhouse hazards other than those specifically covered and should be provided in locations in accordance with NFPA Standard 10.

## 15-8. Detections

*a. Thermal detectors.* Thermal detectors are best suited for locations within equipment such as generators or near flammable fluids.

*b. Ionization detectors.* Ionization detectors are best suited for gases given off by overheating, such as electrical cables or a smoldering fire. Location near arc-producing equipment should be avoided. They are not suited for activating $CO_2$ systems.

*c. Photoelectric detectors.* Photoelectric detectors are best suited for the particles given off by an open fire as caused by a short circuit in electrical cables. Their use in staggered locations with ionization detectors along a cable tray installation would provide earliest detection. They are not suited for activating $CO_2$ systems.

*d. Location.* Detectors should be located at or near the probable fire source such as near cable trays or in the path of heating and ventilating air movement. In areas where combustible materials are not normally present, such as lower inspection galleries, no coverage may be appropriate.

*e. Reliable detection.* The earliest “reliable” detection is required. The detector type or types, location, and adjustment should be carefully considered. The detector sensitivity adjustment should be adjusted to eliminate all false alarms. A fire detector system should be provided in the cable gallery and spreading rooms of all powerhouses.

*f. Alarm system.* The power plant annunciation and, if applicable, the remote alarm system should be used to monitor the fire detection alarms. An alarm system should be provided for each area. Properly applied, these systems will provide more reliable and useful alarm data than the alarm monitor specified in the fire codes.

## 15-9. Isolation and Smoke Control

Smoke and fire isolation is probably the most important fire control item. Smoke inhalation is one of the major causes for loss of life. The toxic fumes from a minor fire could require total evacuation of the powerhouse. Many of the existing heating, ventilating, and air conditioning systems contribute to spreading the smoke as they encompass the entire powerhouse or have a vertical zone composed of several floors. The fire area should be isolated by shutting down the ventilating system or exhausting the air to the outside where feasible to prevent the spread of smoke and to provide visibility for fire fighting reentry to the area. In most cases, the available oxygen is sufficient to support combustion, and little can be gained by not exhausting the smoke. Smoke and fire isolation should be provided in areas where isolation can provide a real benefit. The requirements for fire stops should be considered on a case-by-case basis. Where cable trays pass through a floor or wall which could be considered a fire wall, or where cables leave a tray and enter a switchgear or switchboard through a slot, a fire-stop should be considered. A 12.7-mm (1/2-in.) asbestos-free fireproof insulation fireboard can provide the basic seal with the voids being closed by packing with a high-temperature ceramic fiber. Single conduit or single cables which penetrate a fire wall can be sealed with a special fitting. Thick seals should be avoided as they could contribute to an excessive cable insulation operating temperature. For firestopping, refer to TM 5-812-2. A HVAC system using outside makeup air solely dedicated for the control room should be provided to maintain isolation and smoke control. The HVAC system should be capable of pressurizing the control room with outside air during a fire alarm to prevent smoke infiltration. Stairways in manned powerhouses that are used for emergency access and egress should be pressurized with outside air in accordance with ASHRAE recommendations.

## 15-10. Fire Hose

Certain conductor insulation or cable jackets have been associated with fires that resisted extinguishing with conventional fire control methods. These fires are easily extinguished using water. Water should be considered as a safe and effective electrical fire-fighting method. NFPA Standard 803 lists the required consideration for use of water on energized electrical equipment. The safe approach distance to live electrical apparatus with handheld fire hoses connected to the power plant raw-water system has been established by tests. The following discussion is based on using water at 689 kPa (100 psi), water resistance of 1,524 ohm cm (600 ohm in.), and a current of 3 mA or less in the fire hose stream. The safe approach distance varies with the water resistance, pressure, and type of water stream (i.e., solid stream or spray stream). The solid stream water pattern and conductivity is maintained for a greater distance as the size of the solid stream nozzle and the water pressure is increased. Solid stream nozzles less than 32 mm (1.25 in.) in size can be used on live low-voltage (less than 600 V) circuits at all distances greater than 1.5 m (5 ft). Table 15-1 should be used to establish the safe approach distance to electrical equipment. Floor drains, trenches, or curbs should be provided to remove or contain the water and prevent damage to other equipment and areas. Powerhouse designs should provide fire hoses with spray nozzles in all cable galleries and spreading rooms. The use of fixed mounted spray nozzles should be avoided.

**Table 15-1**
**Safe Distance**

| Kilovolts | | Safe Distance | | | |
|---|---|---|---|---|---|
| | | Solid Stream | | Spray Stream | |
| Line to Line | Line to Ground | (m) | (ft) | (m) | (ft) |
| 4.16 | 2.4 | 4.6 | 15 | 1.3 | 4 |
| 8.32 | 4.8 | 6.1 | 20 | 1.3 | 4 |
| 13.80 | 8.0 | 6.1 | 20 | 1.3 | 4 |
| 44.00 | 25.4 | 9.2 | 30 | 1.9 | 6 |
| 115.00 | 66.4 | 9.2 | 30 | 2.5 | 8 |
| 230.00 | 130.0 | 9.2 | 30 | 4.3 | 14 |